(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 154 143 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
14.11.2001 Bulletin 2001/46

(21) Application number: 00900810.3

(22) Date of filing: 19.01.2000

(51) Int Cl.⁷: F02M 25/07, F28D 7/16

(86) International application number:
PCT/JP00/00217

(87) International publication number:
WO 00/43662 (27.07.2000 Gazette 2000/30)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: 20.01.1999 JP 1177799

(71) Applicant: Hino Motors, Ltd.
Hino-shi, Tokyo 191-8660 (JP)

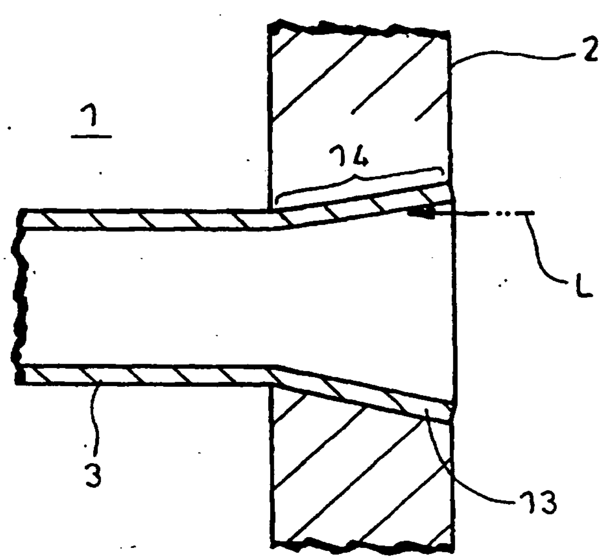
(72) Inventors:
- NAKAGOME, Keiichi, Hino Motors, Ltd
Hino-shi, Tokyo 191-8660 (JP)
- TAKAKURA, Takashi, Hino Motors, Ltd
Hino-shi, Tokyo 191-8660 (JP)

(74) Representative:
LOUIS, PÖHLAU, LOHRENTZ & SEGETH
Postfach 3055
90014 Nürnberg (DE)

(54) EGR COOLER

(57) The invention relates to an EGR cooler in which cooling water is supplied into and discharged from a shell, exhaust gas being passed through tubes from one of hoods to the other hood for thermal exchange of the exhaust gas with the cooling water. Employed is a structure in which the cooling water is prevented from leaking to flow channels of the exhaust gas, so that engine trouble can be prevented from occurring

Fig. 4



Printed by Jouve, 75001 PARIS (FR)

Description

Technical Field

[0001] This invention relates to an EGR cooler attached to an EGR apparatus, which recirculates exhaust gas from an engine to suppress generation of nitrogen oxides, so as to cool the exhaust gas for recirculation.

Background Art

[0002] Known is an EGR apparatus which recirculates part of exhaust gas from an engine in a vehicle or the like to the engine to suppress generation of nitrogen oxides. In such an EGR apparatus, cooling the exhaust gas to be recirculated to the engine will drop the temperature of and reduce the volume of the exhaust gas to lower the combustion temperature in the engine without substantial decrease of output thereof, thereby effectively suppressing generation of nitrogen oxides. To this end, some EGR apparatuses are equipped with, midway of exhaust gas recirculation lines to the engines, EGR coolers for cooling the exhaust gas.

[0003] Fig. 1 is a sectional view showing an example of the above-described EGR cooler wherein reference numeral 1 denotes a cylindrical shell with axial opposite ends to which plates 2 are respectively fixed to close the ends of the shell 1. Penetratingly fixed to the respective plates 2 are opposite ends of a number of tubes 3 which extend axially within the shell 1.

[0004] A cooling water inlet 4 is attached from outside to the shell 1 near one end thereof and a cooling water outlet 5 is attached from outside to the shell 1 near the other end thereof so that cooling water 9 is supplied via the cooling water inlet 4 into the shell 1, flows outside of the tubes 3 and is discharged via the cooling water outlet 5 out of the shell 1.

[0005] The respective plates 2 have, on their sides away from the shell 1, bowl-shaped hoods 6 fixed to the plates 2 so as to enclose end faces of the plates 2. The one and the other hoods 6 provide central exhaust gas inlet and outlet 7 and 8, respectively, so that the exhaust gas 10 from the engine enters via the exhaust gas inlet 7 into the one hood 6, is cooled, during passage through the tubes 3, by heat exchange with the cooling water 9 flowing outside of the tubes 3 and is discharged to the other hood 6 to be recirculated to the engine via the exhaust gas outlet 8.

[0006] In such conventional EGR cooler, however, the end of the tube 3 penetrates into and is fixed to the plate 2 via a brazed portion 11 as shown in Fig. 2 in an enlarged scale. Especially on an outlet side of the exhaust gas 10 as shown, cooling the exhaust gas 10 in the tube 3 will generate condensate containing a vitriolic component which may flow out via the outlet of the tube 3 and corrode the brazing metal (generally nickel brazing metal) constituting the brazed portion 11. If the cooling water 9 should leak therethrough, it may be guided to the engine, causing a trouble.

[0007] Contemplated nowadays is welding the end of the tube 3 to the plate 2 by laser radiation L as shown in Fig. 3. Use of this kind of laser radiation will advantageously bring about laser weld 12 highly resistive against corrosion by the condensate; on the other hand, the weld penetration by the laser radiation L does not reach deep and sufficient weld depth D is hard to obtain, resulting in the laser weld 12 with low bonding strength. If the tube 3 should have undergone excessive thermal expansion, the laser weld 12 may be damaged to cause leakage of the cooling water 9.

[0008] More specifically, upon laser-welding the end of the tube 3 to the plate 2, generally effected is laser radiation L on the side of the plate 2 away from the shell 1 and in parallel with the axis of the tube 3, and welded is a boundary between the plate 2 and the end face of the tube 3 with weld depth D of the order of a wall thickness of the tube 3. As a result, only obtainable is the laser weld 12 having strength lower than that of the tube 3 itself.

[0009] In an actual operation, laser radiation L is effected from directly above, with the tube 3 being stood upright. Therefore, to merely increase the laser intensity for the purpose of increasing the weld depth will disadvantageously result in an increased possibility that the molten portion may flow into the tube 3 to narrow the flow channel. Thus, to increase the laser intensity is inherently limitative.

[0010] Furthermore, as described above, with the laser weld 12 having the shallow weld depth D, the tube 3 is welded to a through-hole 13 of the plate 2 over only a small area on the side away from the shell 1. Therefore, minute crevice may be formed over a major part of the boundary between the through-hole 13 and the tube 3. In this crevice, cavitation may occur due to variation of hydraulic pressure derived from minute vibrations of the tube 3, resulting in generation of crevice corrosion in a deepest portion of the crevice (a portion abutting on the laser weld 12). As a result, the end of the tube 3 may be damaged to cause leakage of the cooling water 9.

[0011] The present invention was made in view of the above facts and has its object to prevent the cooling water from leaking out to the flow channels of the exhaust gas, thereby preventing engine trouble from occurring.

Summary of The Invention

[0012] An EGR cooler according to claim 1 of the invention comprises a cylindrical shell, plates fixed to axial opposite ends of said shell so as to close the ends of the shell, hoods fixed to sides of the plates away from said shell so as to enclose end faces of the plates, tubes extending axially within the shell and having opposite ends penetratingly fixed to the respective plates, cooling water being supplied into and discharged from said shell, exhaust gas being passed through said tubes from

one of the hoods to the other hood for thermal exchange of said exhaust gas with said cooling water, and is characterized in that an end of the tube penetrating the plate is formed as a tapered portion with diameter gradually increased toward the side away from the shell, the tapered portion being wholly welded to the plate by laser radiation from the side away from the shell.

[0013] In this manner, when the end of the tube is formed as the tapered portion with diameter gradually increased toward the side away from the shell, the inner periphery of the tapered portion has a shape divergent to the side away from the shell to have a bevel in the form of mortar, so that laser radiation from the side away from the shell can be readily carried out throughout the inner periphery of the tapered portion.

[0014] Then, a resulting laser weld has a high bonding strength, the weld depth being increased to an extent corresponding to the thickness of the plate. Moreover, formation of minute crevice between the tube and the through-hole of the plate is avoided so that no crevice corrosion occurs.

[0015] An EGR cooler according to claim 2 of the invention comprises a cylindrical shell, plates fixed to axial opposite ends of said shell so as to close the ends of the shell, hoods fixed to sides of the plates away from said shell so as to enclose end faces of the plates, tubes extending axially within the shell and having opposite ends penetratingly fixed to the respective plates, cooling water being supplied into and discharged from said shell, exhaust gas being passed through said tubes from one of the hoods to the other hood for thermal exchange of said exhaust gas with said cooling water, and is characterized in that an end of the tube penetrates into a through-hole of the plate which is formed with a notch on the side toward the shell, and is welded to the plate by laser radiation from the side away from the shell such that a laser weld reaches the notch.

[0016] In this manner, with the through-hole of the plate being formed with the notch on the side toward the shell, an unwelded portion is left as the notch widely opened to the shell when the end of the tube is welded to the plate by means of laser radiation from the side away from the shell such that the laser weld reaches the notch. As a result, no minute crevice is formed between the tube and the through-hole of the plate and no crevice corrosion occurs. It is therefore possible to have a structure which, under the condition that no crevice corrosion occurs, has the laser intensity increased to such a degree that no portion melted by the laser radiation will flow into the tube to narrow the channel, and the weld depth increased as much as possible to increase the bonding strength of the laser weld as high as possible.

[0017] An EGR cooler according to claim 3 of the invention comprises a cylindrical shell, plates fixed to axial opposite ends of said shell so as to close the ends of the shell, hoods fixed to sides of the plates away from said shell so as to enclose end faces of the plates, tubes extending axially within the shell and having opposite ends penetratingly fixed to the respective plates, cooling water being supplied into and discharged from said shell, exhaust gas being passed through said tubes from one of the hoods to the other hood for thermal exchange of said exhaust gas with said cooling water, and is characterized in that the tubes penetrate into and are fixed to the plate via brazed portions such that an end of the tube extends out from the plate by a predetermined length and the extending end of the tube penetrates into and is fixed to a sub plate by laser weld, whereby said sub plate covers said brazed portions.

[0018] Thus, such covering of the plate with the sub plate will cause any condensate containing a vitriolic component, which may be generated by cooling the exhaust gas in the tube and may flow out via the outlet of the tube, to be isolated by the sub plate to which the tubes penetratingly fixed via the laser welds having high resistance against corrosion such that no condensate contacts the brazed portions of the plate. As a result, corrosion of the brazing filler metal constituting the brazed portions due to the condensate is positively avoided while the bonding strength of the tubes to the plate is kept high by the brazed portions. Even if water should leak due to any crack created in the brazed portions, the cooling water is dammed by the sub plate to stay between the sub plate and the plate.

[0019] An EGR cooler according to claim 4 of the invention comprises a shell in the form of a cylindrical container, tubes extending axially within the shell and having opposite ends penetratingly fixed to axial opposite ends of said shell, cooling water being supplied into and discharged from said shell, exhaust gas being passed through said tubes for thermal exchange of said exhaust gas with said cooling water, and is characterized in that the tubes have increased diameter and thickness so as to increase cross sectional areas and strength of flow channels, a gas flange being fitted over tips of the respective tubes extruded out of the shell.

[0020] This allows the number of tubes to be reduced to a required minimum and line for recirculation of exhaust gas may be properly branched and directly connected to the gas flange at the tips of the respective tubes extruded out of the shell. Therefore, even if condensate containing a vitriolic component is generated due to cooling of the exhaust gas in the tubes, avoided is its adverse effect such as corrosion on the penetrating fixed portions of the tubes to the shell. If a crack should be generated on the penetrating fixed portions of the tubes to the shell to cause water leakage, the leaked, cooling water leaks out only outside of the shell and is prevented from intruding into the flow channels of the exhaust gas.

Brief Description of Drawings

[0021]

Fig. 1 is a sectional view showing a conventional

EGR cooler;

Fig. 2 is an enlarged sectional view showing details of a penetrating, fixed portion between a tube and a plate in Fig. 1;

Fig. 3 is an enlarged sectional view showing another example of the penetrating, fixed portion between the tube and the plate;

Fig. 4 is an enlarged sectional view showing an embodiment of the invention as set forth in claim 1;

Fig. 5 is an enlarged sectional view showing the tube laser-welded to the plate in Fig. 4;

Fig. 6 is an enlarged sectional view showing an embodiment of the invention as set forth in claim 2;

Fig. 7 is an enlarged sectional view showing the tube laser-welded to the plate in Fig. 6;

Fig. 8 is an enlarged sectional view showing an embodiment of the invention as set forth in claim 3; and

Fig. 9 is an enlarged sectional view showing an embodiment of the invention as set forth in claim 4.

Best Mode for Carrying Out the Invention

[0022] Now, embodiments of the invention will be described with reference to the drawings.

[0023] Figs. 4 and 5 show an embodiment of the invention as set forth in claim 1 in which the same parts as those in Figs. 1 to 3 are denoted by the same reference numerals.

[0024] In this embodiment, with regard to an EGR cooler constructed substantially in the same manner as that described above with reference to Fig. 1, an end of a tube 3 penetrating a plate 2 is formed as a tapered portion 14 with diameter gradually increased toward the side away from a shell 1; the tapered portion 14 is wholly welded to the plate 2 by laser radiation L from the side away from the shell 1.

[0025] In this manner, when the end of the tube 3 is formed as the tapered portion 14 with diameter gradually increased toward the side away from the shell 1, the inner periphery of the tapered portion 14 has a shape divergent to the side away from the shell 1 to have a bevel in the form of mortar, so that laser radiation L from the side away from the shell 1 can be readily carried out throughout the inner periphery of the tapered portion.

[0026] Then, a resulting laser weld 12 has a high bonding strength, the weld depth D being increased to an extent corresponding to the thickness of the plate 2. Moreover, formation of minute crevice between the tube 3 and a through-hole 13 of the plate 2 is avoided so that no crevice corrosion occurs.

[0027] Therefore, according to the above embodiment, the laser weld 12 highly resistant against corrosion allows the tube 3 to be penetratingly fixed to the plate 2 with a high bonding strength, the weld depth D being increased in comparison with the conventional cases. Moreover, formation of minute crevice between the tube 3 and the through-hole 13 of the plate 2 is avoided to prevent crevice corrosion from occurring. As a result, the cooling water 9 can be positively prevented from leaking out to the flow channel of the exhaust gas 10, which eliminates any possibility of the cooling water 9 being guided to the engine, thereby preventing engine trouble from occurring.

[0028] Figs. 6 and 7 show an embodiment of the invention as set forth in claim 2. In this embodiment, an end of a tube 3 penetrates into a through-hole 13 of a plate 2 which is formed with a notch 15 on the side toward the shell 1, and is welded to the plate 2 by laser radiation L from the side away from the shell 1 such that a laser weld 12 reaches the notch 15.

[0029] In this manner, with the through-hole 13 of the plate 2 being formed with the notch 15 on the side toward the shell 1, an unwelded portion is left as the notch 15 widely opened to the shell 1 when the end of the tube 3 is welded to the plate 2 by laser radiation L from the side away from the shell 1 such that the laser weld 12 reaches the notch 15. As a result, no minute crevice is formed between the tube 3 and the through-hole 13 of the plate 2 and no crevice corrosion occurs. It is therefore possible to have a structure which, under the condition that no crevice corrosion occurs, has the laser intensity increased to such a degree that no portion melted by the laser radiation L will flow into the tube 3 to narrow the channel, and the weld depth D increased as much as possible to increase the bonding strength of the laser weld 12 as high as possible.

[0030] Accordingly, also in this embodiment, formation of minute crevice between the tube 3 and the through-hole 13 of the plate 2 can be avoided to prevent crevice corrosion from occurring. As a result, the cooling water 9 can be positively prevented from leaking out to the flow channel of the exhaust gas 10, which eliminates the possibility of the cooling water 9 being guided to the engine, thereby preventing engine trouble from occurring.

[0031] Fig. 8 shows an embodiment of the invention as set forth in claim 3. In this embodiment, tubes 3 penetrate into and are fixed to a plate 2 via brazed portions 11 such that an end of the tube 3 extends out from the plate 2 by a predetermined length and the extending end of the tube 3 penetrates into and is fixed to a sub plate 16 by laser weld 12. Thus, the sub plate 16 covers the brazed portions 11.

[0032] Especially in this embodiment, an outer periphery of the plate 2 is bent toward the axial direction of the tube 3 with a stepped portion being intervened, and the shell 1 and the bonnet 6 are butt-welded with the outer periphery of the plate 2 being therebetween.

[0033] Thus, such covering of the plate 2 with the sub plate 16 will cause any condensate containing a vitriolic component, which may be generated by cooling the exhaust gas 10 in the tube 3 and may flow out via the outlet of the tube 3, to be isolated by the sub plate 16 to which the tubes 3 penetratingly fixed via the laser welds 12 having high resistance against corrosion such that no condensate contacts the brazed portions 11 of the plate

2. As a result, corrosion of the brazing filler metal constituting the brazed portions 11 due to the condensate is positively avoided while the bonding strength of the tubes 3 to the plate 2 is kept high by the brazed portions 11. Even if water should leak due to any crack created in the brazed portions 11, the cooling water 9 is dammed by the sub plate 16 to stay between the sub plate 16 and the plate 2.

[0034] Therefore, according to the above embodiment, the brazed portion 11 can be protected by the sub plate 16 against the condensate of the exhaust gas 10 while kept high is the bonding strength of the tubes 3 to the plate 2 by the brazed portions 11. As a result, corrosion of the brazed portions 11 can be prevented from occurring. Even if a crack may occur in the brazed portion 11 due to a factor other than the condensate of the exhaust gas 10, resulting in water leakage, the cooling water 9 can be dammed by the sub plate 16 to be accumulated between the sub plate 16 and the plate 2. As a result, the cooling water 9 may not be guided to the engine, and engine trouble can be prevented from occurring.

[0035] Fig. 9 shows an embodiment of the invention as set forth in claim 4. Used in this embodiment is a structure with a shell 1 in the form of a cylindrical container; opposite ends of tubes 3 axially extend in a shell 1 and are penetratingly fixed to opposite axial ends of the shell 1, respectively; the tubes 3 are increased in diameter and thickness in comparison with the conventional cases to increase flow sectional areas and strengths of flow channels, which allows the number of tubes 3 to be reduced to a required minimum (for example, three or so). A gas flange 17 is fitted over tips of the respective tubes 3 extruded out of the shell 1.

[0036] More specifically, in the conventional EGR coolers, the tubes 3 are decreased in diameter and thickness for effective cooling of the recirculated exhaust gas 10, which causes a cross sectional area per tube 3 to be decreased, resulting in necessity of using a great number of tubes 3 and of using a structure in which the tubes are supported by the plates 2 for passing of all the tubes 3 into the hoods 6. By contrast, according to this embodiment, the tubes 3 are increased in diameter and thickness in comparison with the conventional cases to increase the cross sectional areas and the strengths of the flow channels, which allows the number of tubes 3 to be reduced to a required minimum.

[0037] However, of course, the shell 1 and tube 3 must be properly increased in length so as to maintain the cooling efficiency as before.

[0038] As described above, when the number of tubes 3 is reduced to a required minimum and the ends of the respective tubes 3 are penetratingly fixed to the axial opposite ends of the shell 1, line for recirculation of exhaust gas 10 may be properly branched and directly connected to the gas flange 17 at the tips of the respective tubes 3 extruded out of the shell 1. Therefore, even if condensate containing a vitriolic component is generated due to cooling of the exhaust gas 10 in the tubes 3, avoided is its adverse effect such as corrosion on the penetrating fixed portions of the tubes 3 to the shell 1. If a crack should be generated on the penetrating fixed portions of the tubes 3 to the shell 1 to cause water leakage, the leaked, cooling water 9 leaks out only outside of the shell 1 and is prevented from intruding into the flow channels of the exhaust gas 10.

[0039] Therefore, according to the above embodiment, it can be positively avoided that the condensate of the exhaust gas 10 has an adverse effect such as corrosion on the penetrating, fixed portions of the tubes 3 to the shell 1. Moreover, even if a crack should occur in the penetrating, fixed portions due to a factor other than the condensate of the exhaust gas 10 to cause water leakage, the leaked cooling water 9 can be positively prevented from intruding into the flow channels of the exhaust gas 10. As a result, the cooling water 9 may not be guided to the engine and engine trouble is prevented from occurring.

[0040] It is to be understood that the EGR cooler of the invention is not limited to the above embodiments and that various changes and modifications may be made without departing from the scope of the invention. For example, the outlet side of the exhaust gas is shown in the drawings; however, similar construction may be applicable on the inlet side of the exhaust gas.

Industrial Applicability

[0041] As described above, the EGR cooler according to the invention is suitable for use in an EGR apparatus for recirculating exhaust gas from the engine to suppress generation of nitrogen oxides.

Claims

1. An EGR cooler comprising a cylindrical shell, plates fixed to axial opposite ends of said shell so as to close the ends of the shell, hoods fixed to sides of the plates away from said shell so as to enclose end faces of the plates, tubes extending axially within the shell and having opposite ends penetratingly fixed to the respective plates, cooling water being supplied into and discharged from said shell, exhaust gas being passed through said tubes from one of the hoods to the other hood for thermal exchange of said exhaust gas with said cooling water, **characterized in that** an end of the tube penetrating the plate is formed as a tapered portion with diameter gradually increased toward the side away from the shell, the tapered portion being wholly welded to the plate by laser radiation from the side away from the shell.

2. An EGR cooler comprising a cylindrical shell, plates fixed to axial opposite ends of said shell so as to

close the ends of the shell, hoods fixed to sides of the plates away from said shell so as to enclose end faces of the plates, tubes extending axially within the shell and having opposite ends penetratingly fixed to the respective plates, cooling water being supplied into and discharged from said shell, exhaust gas being passed through said tubes from one of the hoods to the other hood for thermal exchange of said exhaust gas with said cooling water, **characterized in that** an end of the tube penetrates into a through-hole of the plate which is formed with a notch on the side toward the shell, and is welded to the plate by laser radiation from the side away from the shell such that a laser weld reaches the notch.

3. An EGR cooler comprising a cylindrical shell, plates fixed to axial opposite ends of said shell so as to close the ends of the shell, hoods fixed to sides of the plates away from said shell so as to enclose end faces of the plates, tubes extending axially within the shell and having opposite ends penetratingly fixed to the respective plates, cooling water being supplied into and discharged from said shell, exhaust gas being passed through said tubes from one of the hoods to the other hood for thermal exchange of said exhaust gas with said cooling water, **characterized in that** the tubes penetrate into and are fixed to the plate via brazed portions such that an end of the tube extends out from the plate by a predetermined length and the extending end of the tube penetrates into and is fixed to a sub plate by laser weld, whereby said sub plate covers said brazed portions.

4. An EGR cooler comprising a shell in the form of a cylindrical container, tubes extending axially within the shell and having opposite ends penetratingly fixed to axial opposite ends of said shell, cooling water being supplied into and discharged from said shell, exhaust gas being passed through said tubes for thermal exchange of said exhaust gas with said cooling water, **characterized in that** the tubes have increased diameter and thickness so as to increase cross sectional areas and strength of flow channels, a gas flange being fitted over tips of the respective tubes extruded out of the shell.

Fig. 1

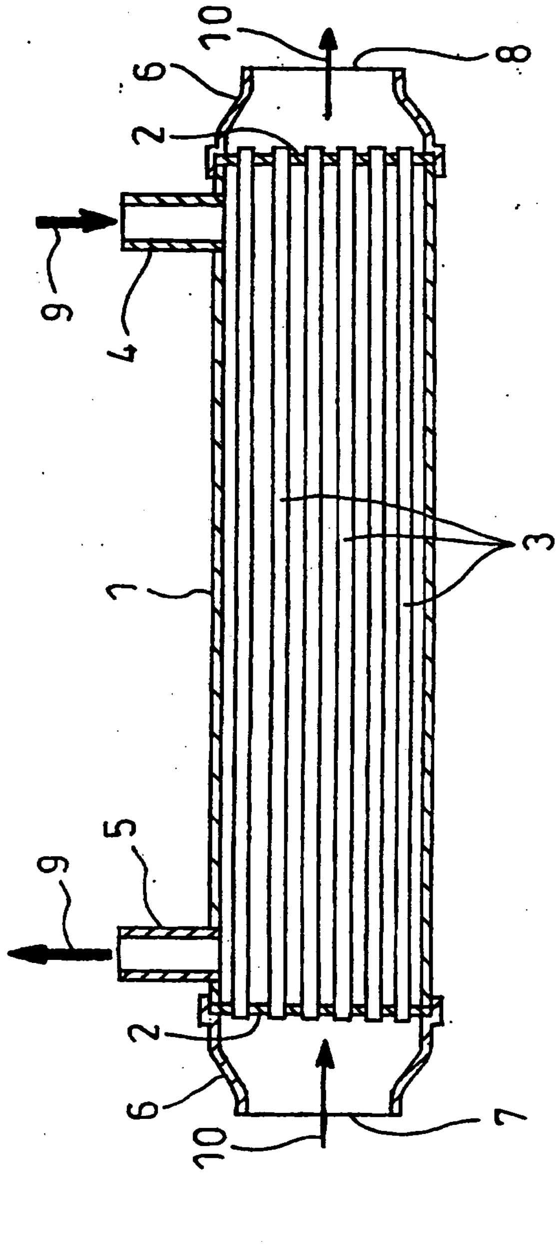


Fig. 2

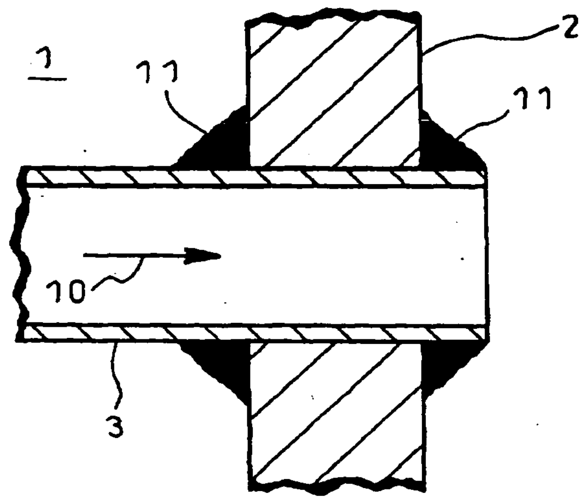


Fig. 3

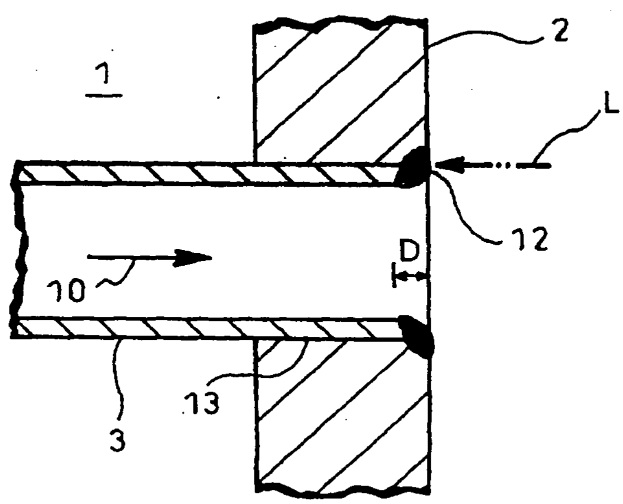


Fig. 4

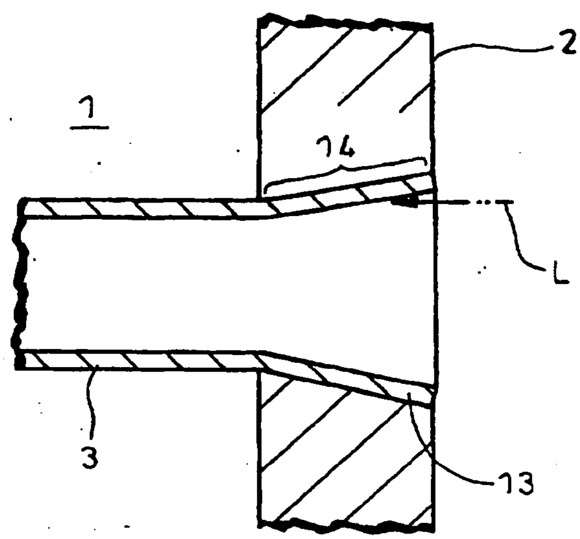


Fig. 5

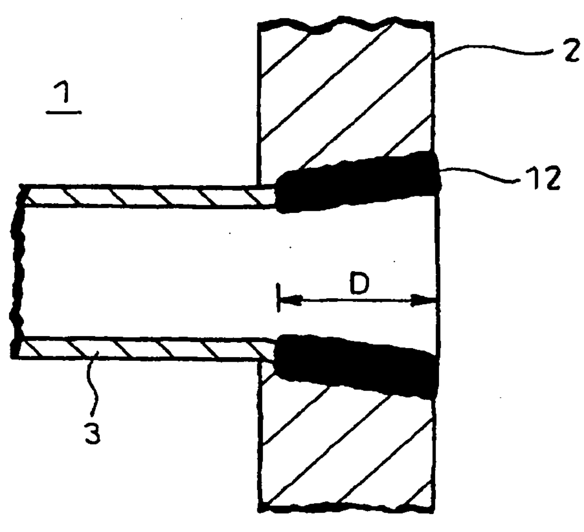


Fig. 6

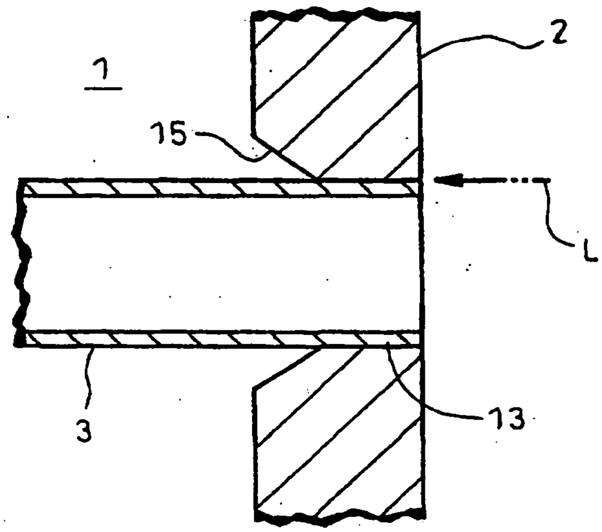


Fig. 7

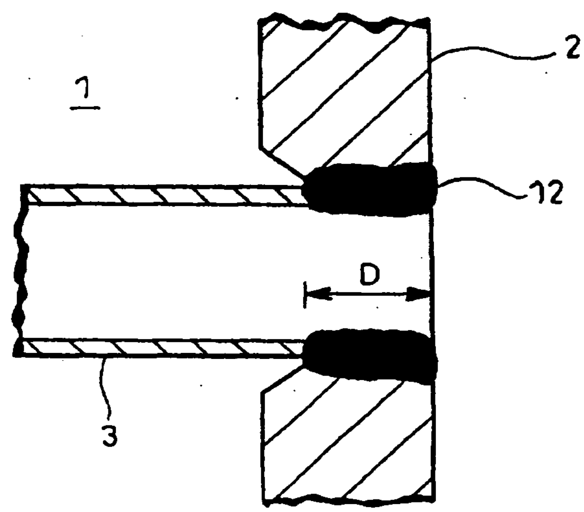


Fig. 8

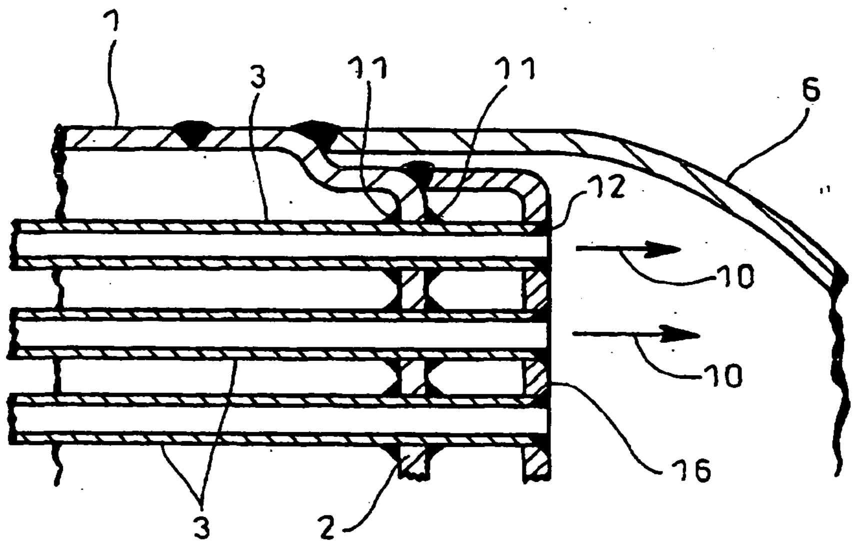
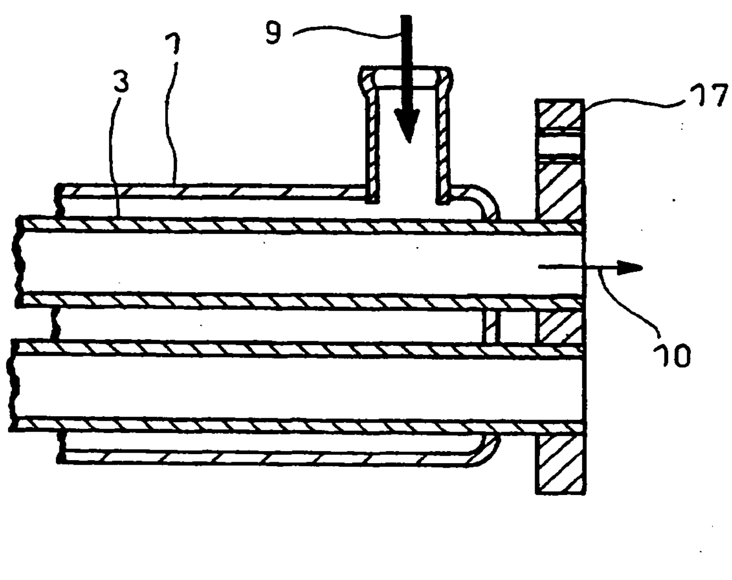


Fig. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/00217

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl⁷ F02M25/07, F28D7/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl⁷ F02M25/07, F28D7/16, F02F9/00, B23K9/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Jitsuyo Shinan Toroku Koho	1996-2000
Kokai Jitsuyo Shinan Koho	1971-1998	Toroku Jitsuyo Shinan Koho	1994-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 45-027697, B (Hitachi, Ltd.), 10 September, 1970 (10.09.70), Fig. 2, . (Family: none)	1
Y	JP, 63-154281, A (Mitsubishi Heavy Industries, Ltd.), 27 June, 1988 (27.06.88), Figs. 1 to 7 (Family: none)	1
Y	JP, 59-009265, B (Hitachi, Ltd.), 01 March, 1984 (01.03.84), Fig. 7 (Family: none)	1
Y	JP, 09-133492, A (EBARA CORPORATION), 20 May, 1997 (20.05.97), Figs. 2, 3 (Family: none)	2
Y	JP, 06-207795, A (Nippon Steel Corporation), 26 July, 1994 (26.07.94), Figs. 1 to 4	3

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 10 April, 2000 (10.04.00)	Date of mailing of the international search report 18 April, 2000 (18.04.00)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/00217

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	& US, 4884470, A	
Y	JP, 07-049241, Y (Kabushiki Kaisha Unosawagumi Tekkosho), 13 November, 1995 (13.11.95), Figs. 1 to 4 (Family: none)	4
A	JP, 57-002995, A (Tokyo Shibaura Denki K.K.), 08 January, 1982 (08.01.82), Figs. 1 to 4 (Family: none)	1-4
A	JP, 09-310996, A (Usui International Ind. Co., Ltd.), 02 December, 1997 (02.12.97), Figs. 1 to 8 (Family: none)	1-4
A	JP, 10-318050, A (Usui International Ind. Co., Ltd.), 02 December, 1998 (02.12.98), Figs. 1 to 5 (Family: none)	1-4
A	US, 5785030, A (Dry Systems Technologies), 28 July, 1998 (28.07.98), Fig. 2 & WO, 98-27323, A & AU, 5794198, A	1-4
A	US, 5732688, A (Cummins Engine Company, Inc), 31 March, 1998 (31.03.98), Fig. 3, Fig. 3A & EP, 848155, A	1-4

Form PCT/ISA/210 (continuation of second sheet) (July 1992)